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(54) Title: WATER-FILTER LIFETIME INDICATOR

(57) **Abstract:** An indicator, and method of indicating, the expiration of substantially the predetermined useful life of a water filter, use color change in a simple but very effective manner. The water migrates into a color change mechanism which may include a porous medium, and causes first and second reagents to react producing a color change. The reaction system between the reagents may be selected from the group consisting essentially of chelation of a metal ion by a chelating agent, reaction of an acid/base with a pH indicator, reaction of an electron donor/acceptor with a redox indicator, and an enzymatic reaction between an enzyme and a substrate. The color change mechanism displays a gradual advance of the color change over time, and may incorporate a scale to display the elapsed time. A mask containing scale indicia may be used to relate the progress of the diffusion to substantially the predetermined useful life of the filter.

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WATER-FILTER LIFETIME INDICATOR

BACKGROUND OF THE INVENTION

The present invention relates to an elapsed time indicator for indicating the product lifetime of a drinking-water filter. More particularly the present invention relates to a water-filter cartridge for a portable bottle or jug-type water filter where the filter cartridge has an integral indicator which indicates to the user when to change the filter, primarily in terms of the elapsed time since first use of the filter. Such invention is also useful for a myriad of other purposes when elapsed time is of importance and is either automatically enabled by an event or deliberately manually enabled.

The need to periodically replace water filters, both because their active components become exhausted and also due to health concerns about the potential accumulation of bacteria in the filter, and various indicator and cut-off means to accomplish this objective are well known in the art. For relatively large filtration devices or for on-line filters, it is cost-justifiable to use an electronic indicator such as those exemplified by U.S. Patents 5,236,578 and 5,679,243. Also known are complex mechanical systems which operate on the basis of measuring the total volume of water filtered, for example U.S. Patent 5,527,451. However for inexpensive, jug-type filters and bottle-type filters, there is a need for a less expensive indicator that shows when to change the filter. Some simple mechanical means are known in the art for this purpose. One approach uses a simple manually-operated dial, either as part of the jug or manually placed on the filter cartridge each time said filter cartridge is replaced. When using such dial indicators, the user is required to manually advance the dial each time the jug is refilled. For example, U.S. Patent 4,986,901 describes the use of a dial with indicia which show when the filter should be replaced. In other embodiments, such a dial enables the manual setting of a date representing the filters date of replacement. A slightly more sophisticated implementation of the same concept has been implemented by building a dial into the lid of the water filtration pitcher or jug. For example, U.S. Patent 5,190,643 discloses a mechanism for opening an aperture in the lid of the pitcher through which the water filtration vessel is filled.

At each opening of this aperture mechanism, the dial is moved one position forward. When a predetermined number of increments have been reached, the aperture mechanism will no longer open until it is reset. The user is expected to then replace the water filter and manually reset the mechanism. In the worst case, the user may at this point choose to simply raise the lid to refill the jug instead of using the aperture mechanism.

The above mechanisms all suffer from the disadvantage that they require some manual action by the user to set and reset them. An advance on these systems has been achieved by using an automatic mechanical mechanism to count the number of times that the vessel is filled, thereby giving a rough volume estimation. U.S. Patents 5,536,394, 5,785,844 and 5,882,507 describe a filter-cartridge lifetime indicator mechanism which uses a float that is moved one position along an incremental path each time the filling of the vessel causes the float to be lifted. This disadvantage of this type of approach is that it is relatively expensive and thus is disadvantageous to provide it as an integral part of the filter. However when placed externally, for example on top of the filter cartridge, this approach then suffers from the common disadvantage of all indication means external to the filter cartridge: lack of consumer confidence. When the indicator is external to the cartridge, users tend to believe that the indicator does not present a true picture of the status of the cartridge and this consumer confidence issue has caused filter cartridge replacement rates to be well below manufacturer recommended levels.

There is a further disadvantage to all the above volume-related replacement indicators:

while it is correct that filter cartridge replacement should reflect usage, it is important that very low usage should not cause a potential bacteriological risk. The simple, volume-related mechanical mechanisms described above all suffer from the potential danger that, when refilled rarely, the indicator will still show that the filter does not need to replaced when in fact, from a bacteriological perspective it should already have been removed as a potential health threat. Thus there is an inherent health disadvantage in providing a filter cartridge with an indication means which does not take elapsed time into account.

An alternative approach for measuring the actual utilization of the active components in the filter cartridge is described in U.S. Patent 5,076,912 which describes the use of a color indicator bonded to an ion exchange resin within the filter cartridge, where said indicator changes color when the ion exchange capacity of the filter becomes exhausted, this approach shares the previously noted disadvantage that, if the filter is only used rarely, the time taken before the indicator signals that it should be replaced could be beyond the point where the filters replacement would be warranted from a bacteriological point of view. Additionally, this approach suffers from the disadvantage that the color indicator could potentially be released into the drinking water, thereby posing a potential health hazard.

There is thus an advantage to simply measuring an elapsed time since the time of first use; so that even a filter which is hardly used would still get replaced after a specified time. In accordance with this concept, U.S. Patents 4,998,228 and 5,457,665 describe a time-based approach to replacement of the filter, where a mechanical mechanism is used to implement a clock. The mechanism employed is the use of a sphere placed inside a tube filled with a viscous liquid. The tube is attached to the water filter cartridge. When the sphere is released, it gradually rises up inside the tube over a time period that can exceed a month. When the sphere reaches the top of the tube, a suitably placed window can show this as a color change indicating that the filter should be replaced. The main disadvantage of this approach is that it requires an explicit activation step by the user in order to release the sphere on its upward journey and thereby start the timer. If this activation is not performed then the lifetime indicator is not triggered and the objective of signaling a replacement at least within certain time parameters is not achieved; potentially giving a false sense of security with respect to the use of the filter. The other disadvantage of this approach is that, being based on a mechanical principle, it requires plastic parts and assembly and thus is significantly more expensive than the approach used by the current invention.

Also known in the art are chemical timers and diffusion clocks; examples of such timers including: U.S. Patent 3,520,124 in which two reagent-bearing porous matrices are brought into contact, resulting in a time dependent color changing reaction; U.S. Patent 4,028,876 in which two reagents slowly mix through a porous

medium to produce a color change; U.S. Patent 4,195,058 in which a vapor gradually penetrates a vapor permeable barrier to react with a second reagent and produce a visual color change; U.S. Patent 4,229,813 in which a silicon oil slowly diffuses along a porous strip; U.S. Patent 4,248, 597 in which a substance penetrates through a permeable membrane to cause a pH indicator to undergo a color change; U.S. Patent 4,292,916 in which components of a carrier mixture react physically and/or chemically with one or more receptive layers to give either a changing color display or to cause the appearance or disappearance of indicia; U.S. Patent 4,404,922 in which gradual permeation of a fluid into a sachet causes the appearance or disappearance of indicia on said sachet; U.S. Patent 5,053,339 in which an acid diffuses through a barrier to cause a pH indicator to change color; U.S. Patent 5,317,987 in which gradual pitting of a barrier between two reagents causes said reagents to react with each other after a given time thereby causing a color change; U.S. Patent 5,446,705 in which an adhesive layer dissolves a dye which then migrates through said adhesive layer to cause a visible change; U.S. Patent 5,633,835 in which an adhesive layer first dissolves a barrier and then dissolves a dye which then migrates through said adhesive layer to cause a visible change; and U.S. Patent 5,667,303 in which a viscoelastic material slowly migrates into a into a diffusely light-reflective porous medium in order to provide a visually observable indication.

Beside the use in conjunction with a water filter there are numerous other applications for the use of an inexpensive timing mechanism. An example would be to use to measure the elapsed time food has been in storage. For use by the consumers in particular those that frequently stores food and desires to know how long specific items have been in storage. As an option to this invention the user may actuate the timing indicator which in turn provides a visual readout graduated in days, or such other unit of measurement as may be deemed appropriate and designed into the timing indicators. For uses of this nature a self-contained water reservoir is an independent component of the indicator. To actuate the indicator a separating membrane is ruptured allowing a small amount of water to contact the indicator mechanism.

SUMMARY OF THE INVENTION

Whereas various mechanical and electronic mechanisms for indicating when to replace a drinking-water filter cartridge are known, the present invention as defined hereinafter utilizes concepts from the field of chemical timers and diffusion clocks in order to implement a water-filter lifetime indicator. Such timers and clocks can be very inexpensively fabricated, but have never been designed so as to function as filter cartridge lifetime indicators. Nor have such timing devices been conceived that function when immersed in water for short or prolonged periods, in a warm or cool environment while retaining reasonable performance accuracy.

Advantages to using a chemical timer, as described in the present invention with the aforementioned characteristics, are:

1. The timing device may be immersed in water over its extended life without leaching substances into the water.

2. The timing device may be used as an external indicator of elapsed time showing the numbers of days since activation.

3. A timing device, which may be automatic in its actuation or designed to permit manual, planned activation.

4. A timing device which may be inexpensive, as well as a reliable indicator of elapsed time in days with better than ±20 percent accuracy.

It is therefore one of the objects of the present invention to provide a substantially lifetime indicator for drinking water filters which ensures that a periodic replacement of the filter cartridge is signaled to the user. Accordingly, one of the objectives of the current invention is to obviate the disadvantages of the forgoing devices by implementing a primarily time-based lifetime indicator for a water-filter.

It is a further object of the invention that the substantially lifetime indicator will be integral to the filter cartridge, in order to maximize the likelihood that the user will respond by changing the filter cartridge, thereby minimizing any potential bacteriological risk.

It is a still further object of the invention that the construction of the substantially lifetime indicator be such that it can be fabricated for minimal cost, so

that it will be cost-effective to place it on each and every filter cartridge as opposed to having an indicator built into the jug, the lid, or manually attached to the filter cartridge.

It is a still further objective of the current invention that the substantially lifetime indicator operate in a fool-proof manner in conjunction with water filter applications by obviating the requirement that the user take an explicit action simply in order to activate the indicator.

It is a still further object of the present invention to enable maximum ease of use and foolproof operation having the substantially lifetime indicator activated by the first contact of the indicator with water.

It is a still further object of the invention to ensure that the operation of the substantially lifetime indicator does not cause the release of any potentially dangerous chemicals into the water being filtered.

It is a still further object of the invention to enable the determination of the filter cartridge lifetime by some combination of elapsed time and water volume processed.

In one preferred embodiment of the present invention, the substantially lifetime indicator is recessed into the top of a carafe style pour through water-filter cartridge such that the indicator is readily viewable by the user each time the cover of the water filtration vessel is removed to fill said vessel with water.

In a second preferred embodiment of the present invention, the substantially lifetime indicator is to the side or bottom of an exit style filter cartridge as used in portable personal and sport type water filter bottles such that the indicator is readily viewable by the user each time the top and attached filter is removed to fill the bottle with water.

A somewhat different embodiment of the basic design for independent self contained application of the invention occurs with the incorporation of a sealed water reservoir. Activation, in this application, is manually controlled by rupturing a membrane separating the water from indicating mechanism. An indicator of this nature would be useful to adhesively affix to a food storage container. A further enhancement would be to graphically show time (days as an example) along the projected path of the indicator. This would function in the same manner as a thermometer with a degree scale.

According to one aspect of the present invention there is provided a method of indicating the expiration of substantially the predetermined useful life of a water filter comprising: Operatively connecting a water filter, a pad containing a zinc salt or dye, and a diffusion strip of sol-gel doped with PAR dipped paper. Drawing water associated with the filter into contact with the pad to produce a solution. Slowly diffusing the solution through the diffusion strip so as to produce a color change. And viewing the color change via a mask containing indicia that relates the progress of the diffusion to substantially the predetermined useful life of the filter.

According to another aspect of the invention there is provided a substantially lifetime indicator device for a drinking-water filter comprising: A fluid migration conduit which facilitates fluid migration therein, having a first end and a second end. The first end having an aperture for receiving fluid, and the second end comprising a transparent section allowing an external viewer to observe a color change therein. And a color-changing mechanism which is activated by water and positioned within the conduit, so that when water comes into contact with the indicator, a portion of the water enters the conduit first end, thereby activating the color-changing mechanism which can be viewed at the second conduit end after a predetermined time interval.

The device may further comprise a porous medium in the conduit, so that water that has entered the conduit by the aperture slowly migrates through the medium thereby providing the visual indication which progresses down the length of the porous medium over time. The device may further comprise a first reagent located within the conduit so that the water dissolves the first reagent and the solution containing the first reagent then migrates through the porous medium. The device may further comprise a solid dye located within the conduit, and the water dissolves the solid dye so that a dye solution then migrates through the porous medium. The porous medium may also contain a second reagent which reacts with the first reagent thereby producing a color change, and the porous medium may be impregnated with the second reagent, or the porous medium may be doped with the second reagent.

Where first and second reagents are provided, the reaction system therebetween may be selected from the group consisting essentially of chelation of

a metal ion by a chelating agent, reaction of an acid/base with a pH indicator, reaction of an electron donor/acceptor with a redox indicator, and an enzymatic reaction between an enzyme and a substrate. In this case the metal ions may be selected from the group consisting essentially of zinc, copper, iron, and calcium ions, the chelating agent may be selected from the group consisting of 1,10 phenanthroline, zincon, and 2,2'-biquioline (cupron) and PAR, the acid/base reagents may be selected from the group consisting essentially of hydrochloric acid, citric acid, ascorbic acid, sodium hydroxide, and sodium hydrogen phosphate, the pH indicators may be selected from the group consisting essentially of bromothymol blue, methyl red, and cresol red; the electron donor/acceptors may be selected from the group consisting essentially of bleaching powder and vanadium salts; and the redox indicators may be selected from the group consisting essentially of nphenylanthrancilic acid and bleachable dyes. The porous medium itself may be selected from the group consisting essentially of cellulose-based material, paper, sol-gel, silica gel, polymeric micro-porous materials, and particle-filled polytetrafluroethylene, or a combination of at least two of the above mentioned porous materials.

The mechanism for migration down the length of the porous medium may be selected from the group consisting essentially of diffusion and capillary action. Where the porous medium is initially opaque the migration of the water into the pores may cause the pores medium to become substantially transparent, thereby resulting in a visually observable change. For example, the porous medium may have a colored background located therebelow, so that when the porous medium becomes substantially transparent the background color shows through and can be observed from above as a visible color change.

The porous medium may be colored by the migration of the dye solution into its pores, resulting in a visually observable change. The fluid migration conduit may employ capillary action to draw water toward the color changing mechanism.

The indicator may further comprise a water reservoir serving to drive the migration of fluid through the color changing mechanism; and wherein the volume of the reservoir determines the extent of migration through the color-changing mechanism. For example, the water reservoir may be sufficiently large to drive the

migration after only one contact of the water filter with water, so that one filling of the water filter is sufficient to drive the indicator for the entire lifetime of the water filter cartridge. The reservoir is sufficiently small so as to only drive the migration by a small amount, so as to implement a relationship between the number of fillings of the water filter and the extent of the migration, so that the indicator substantially determines the effective lifetime of the water filter by also taking into consideration the number of times that the water filter is refilled.

The device may further comprise a partially transparent mask located above the conduit second end, the mask presenting the underlying color change of the the color-changing mechanism via graphic indicia located on the mask by one or more transparent windows enabling the underlying color change to show through. The color changing mechanism displays a gradual advance of the color change over time. The device may incorporate a scale to display the elapsed time.

The invention also relates to a drinking-water filter cartridge incorporating the filtration media and indicator as described above.

According to another aspect of the present invention there is provided a substantially lifetime indicator device for a water filter comprising: A small water reservoir for capturing water at the time that a water filter is filled. An element (e.g. thread) drawing the water into contact with a pad containing a zinc salt so that the zinc ions located on the pad are carried into solution. A diffusion strip formed by dipping paper in sol-gel doped with the chelating agent PAR. And the reservoir element and strip positioned so that the solution slowly diffuses through the diffusion strip where the zinc ions undergo a chelation reaction with the PAR, yielding a color change from yellow to red, and so that the diffusion front of the color change slowly proceeds along the paper strip and is viewed via a mask containing indicia that relate the progress of the diffusion front to the effective lifetime of the water filter.

According to another aspect of the present invention there is provided a substantially lifetime indicator device for a water filter comprising: A small water reservoir for capturing water at the time that a water filter is filled. A thread drawing the water into contact with a paid containing a dye so that the dye is carried into solution. A diffusion strip consisting of a micro-porous material. And

wherein the reservoir, thread and diffusion strip are positioned so that the solution slowly diffuses through the diffusion strip so that the diffusion strip undergoes a color change due to the absorption of the dye, and so that the diffusion front of the color change slowly proceeds along the diffusion strip and is viewed via a mask containing indicia that relate the progress of the diffusion front to the effective lifetime of the water filter.

The invention also relates to a substantially lifetime indicator device for a drinking-water filter wherein the indicator comprises a liquid which migrates slowly through a porous media resulting in an observed color change, and wherein the appearance of the color change corresponds to the intended effective lifetime of the water filter. The device may incorporate a self-contained but independent water reservoir which may be manipulated in such a manner as to bring the contained water into contact with the timing mechanism in such a manner as to actuate the timing function.

The invention will now be described in connection with certain preferred embodiments with reference to the following illustrative figures so that it may be more fully understood.

With specific reference now to the figures in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 shows a filter cartridge with a substantially lifetime indicator recessed into the top of the filter cartridge;

FIGURE 2 shows a cross-sectional view of the substantially lifetime indicator;

FIGURE 3 shows a laminated package containing a slow liquid-migration mechanism;

FIGURE 4 shows a graph of the progress of a diffusion front along a micro-porous strip under different filling regimes;

FIGURE 5 shows a preferred embodiment for displaying the progress of the substantially lifetime indicator;

FIGURE 6 shows a filter cartridge with integral substantially lifetime indicator mounted inside a jug-type water filtration vessel;

FIGURE 7 shows the parts and assembly of a linear substantially lifetime indicator and its preferred attachment to a drinking water filter cartridge used in a bottle;

FIGURE 8 shows the parts and assembly of a round substantially lifetime indicator and its preferred attachment to a drinking water filter cartridge used in a bottle;

FIGURE 9 shows the preferred attachment location of a linear or round substantially lifetime indicator to the side of a drinking water filter cartridge used in a pitcher; and

FIGURE 10 shows a self contained substantially lifetime indicator for assembly to an independent object, such as a food storage container, in which the indicator is actuated by rupturing the membrane separating the water reservoir from the timing mechanism and an elapsed timing scale in weeks is also shown.

DETAILED DESCRIPTION OF THE DRAWINGS

In the following figures similar numbers are used to designate similar parts. An exemplary water filter cartridge according to the present invention is shown in FIGURE 1. The filter cartridge 10 contains a recessed section 12 in its upper surface 14 suitable for the insertion of the substantially lifetime indicator 13. Also viewable from above are the perforations 16 which admit water to the substantially lifetime indicator 13 together with indicia showing the status of said indicator. In a preferred embodiment, such indicia will include a clear end-point 18 and preferentially also graphic symbols or alphanumeric indicia showing the gradual advance to said endpoint 18. Preferably, at least part of the upper surface of the substantially lifetime indicator 13 is transparent, enabling a color change in the

underlying mechanism to be viewed through said transparent sections. In a preferred embodiment, the end-point 18 and indicia 19 are transparent and a diffusion strip is mounted underneath them. As a color-changing diffusion front advances along said strip the indicia are then seen to change color over time. In a preferred embodiment, the starting color of the indicia is the same as the background color of the lifetime indicator 13, and thus any color change of the indicia 19 and end-point 18 stands out clearly. In a preferred embodiment, the final color of the end-point 18 is red; a transition to red being readily understandable as a sign that the filter cartridge should be replaced.

Referring now to FIGURE 2, there is seen an exemplary embodiment of the cross-section of the top of the filter cartridge 20 where the lifetime indicator 21 has been inserted into a recess in the upper surface. Said indicator comprises a fluid migration conduit for facilitating fluid migration therein, wherein said conduit has a first end and a second end, wherein said first end has an aperture for receiving fluid, and wherein said second end consists of a transparent section for allowing an external viewer to observe a color change therein; and color-changing means which are activated by water and positioned within said conduit; whereby, when water comes into contact with said indicator, a portion thereof enters said first end, thereby activating said color changing means which can be viewed at said second end after a predetermined time interval. Advantageously, this indicator is initiated and runs thereafter by the simple contact of water with the water filter cartridge, and therefore does not require an explicit action by the user specifically to trigger the activity of said indicator.

In a preferred embodiment said indicator preferentially comprises perforations 22 for admitting water to said conduit, a reservoir 24 for said water, and a laminated package 26 containing the said color changing means. The change of color over time is viewed via indicia on an upper surface 28 which is at least partially transparent. In a preferred embodiment, when the water filtration vessel is filled, the filter cartridge comes in contact with water, and some of this water enters the perforations 22 and fills the reservoir 24. The water in this reservoir is in direct contact with the edge of the laminated package 26 and serves to drive the slow liquid-migration mechanism within this package.

Referring now to FIGURE 3, there is seen an exemplary embodiment of a slow liquid-migration mechanism where the migration mechanism used is diffusion through a micro-porous medium. In a preferred embodiment the diffusion medium is a doped sol-gel and the color changing reaction system is a chelation reaction. In said embodiment, the mechanism comprises a laminated package 30 containing a zinc-impregnated paper pad 32, a doped sol-gel strip 34 and a thread 36. The thread 36 serves to introduce water via capillary action into the package 30 where it wets the impregnated paper pad 32 thereby dissolving the zinc ions.

Advantageously the capillary action ensures that the dissolved reagent is unable to leach out of the laminated package 30 and potentially enter the drinking water. The resulting zinc solution then proceeds to diffuse slowly through the doped sol-gel strip 34, reacting as it proceeds with the dopant; in this case the chelating agent 4-(2-pyridylazo)resorcinol monosodium salt, hereinafter PAR, is used to yield a color change from yellow to red. As the diffusion front proceeds up the doped sol-gel strip, the sharp color change which results is clearly seen from above via the partially transparent indicia mounted above the strip. Thus when a predetermined end-point is reached, the user clearly sees that the filter cartridge is supposed to be replaced.

In this embodiment the support material for the doped sol-gel is standard laser quality paper (80g/m^2) paper which is cut into about 1 cm by about 2.5 cm strips and dip coated with the PAR-doped sol-gel. The preparation of the doped sol-gel liquid is performed as follows: About a 5 ml solution of tetraethoxysilane (TEOS) is added to a stirred solution consisting of about 10 ml ethanol, I .6 ml triply distilled water, about 4 drops of concentrated (33%) hydrochloric acid (HCl) and about 0.1 g of PAR. After stirring for a further approximately 5 minutes, about 0.3 g of hexadecyltrimethylammonium bromide is added and stirred until the solution becomes homogeneous. The solution is stirred for a further approximately two hours. The dipping of the paper into this sol-gel liquid is performed as follows: The paper strip is held by a dipping machine at one end. It is lowered into the non-stirred solution and then is withdrawn at a rate of about 0.08 cm/sec. It is then left to dry at about 50°C in an oven for at least about 24 hours to complete curing. The impregnated paper pad consists of Whatman No.1 filter paper which is dipped into about an 1.5 M methanol or aqueous solution of

$ZnCl_2$, dried at about 60°C and then cut into squares of about 0.75 cm by 0.75 cm. This choice of reaction system in the preferred embodiment is especially advantageous as, even if the package were to split open, no pollution of the drinking water would occur as zinc ions are an acceptable constituent of drinking water at levels up to about 5 mg/l and the PAR remains entrapped as a dopant within the sol-gel matrix and therefore can not leach out. The lamination is performed at about 150 degrees C with about a 250 micron laminate. Before lamination a cotton thread (or other thread with like wicking or related properties), like thread 36, is placed across the zinc pad that is positioned on one end of the sol-gel paper strip.

Referring now to FIGURE 8, there is seen an additional preferred embodiment which utilizes the advantage of a capillary wicking mechanism mentioned earlier, in a geometric configuration which is less costly in high speed manufacture. In this embodiment, the three components described in reference to FIGURE 3 are still employed, but in this case exhibit radial rather than axial symmetry. In the radial embodiment, the wicking thread becomes a ring of porous material which serves the same function. The zinc impregnated pad becomes a disk of impregnated material which serves the same function. The zinc impregnated pad becomes a disk of impregnated material, and the doped sol-gel strip becomes a disk of doped sol-gel paper. In this configuration, a significant manufacturing issue of how to align a segment of thread with larger pieces of paper is eliminated. The other aspects of this design are similar to that described in reference to FIGURE 3 in that perforations in the laminate provide a means of admitting water to the fluid migration conduit consisting of wicking material, zinc reservoir, and color changing medium. In certain filter cartridge designs, particularly those involving smaller sized elements, the radial indicator configuration described here also facilitates placement of the timer indicator on the filter element (Fig 8).

As is apparent to one skilled in the art, a number of alternative liquid-migration media and a number of alternative reaction mechanisms are feasible. A number of micro-porous media enable a slow-diffusion effect to be implemented; examples include Empore™ particle-filled Teflon (available from Minnesota Mining and Manufacturing Company, St. Paul, Minnesota, USA), silica gel or a micro-

porous polymeric material such as Teslin™ (available from PPG Industries Inc., Pittsburgh, Pennsylvania, USA). Other materials suitable for a migration media are cellulose-based materials such as paper where, without wishing to be bound by theory, both capillary action and diffusion would contribute to the migration effect. Some alternative systems capable of producing a similar color change to that of the above described preferred embodiment are listed below:

-- To implement other chelation reactions, alternative chelating agents such as 1, 10 phenanthroline, zincon, or 2,2'-biquioline (cupron) can be incorporated or doped into the porous medium while alternative liquid reagents that would migrate into the porous medium can include solutions of metal ions such as copper ions, iron ions and calcium ions.

-- To implement acid/base reaction systems, suitable pH indicators include bromothymol blue, methyl red, cresol red can be incorporated or doped into the porous medium, and suitable acid/base liquid reagents that would migrate into the porous medium can include the acids: hydrochloric acid, citric acid and ascorbic acid and the bases: sodium hydroxide and sodium hydrogen phosphate.

-- To implement redox reactions, redox indicators such as n-phenylanthrancilic acid or a bleachable dye can be incorporated or doped into the porous medium while alternative liquid reagents that would migrate into the porous medium can include solutions of bleaching powder or of vanadium salts.

-- To implement an enzymatic reaction, an enzyme such as a lipase can be incorporated or doped into the porous medium together with a pH indicator while a liquid substrate such as tricaproin would migrate into the porous medium. In a preferred embodiment the reaction product of the enzymatic reaction of a lipase and tricaproin is caproic acid; said acid producing a color shift in the pH indicator. And

-- To implement a non-reactive system, a colorless porous medium with no embedded reagents can be slowly penetrated by a water-soluble dye which is dissolved by the incoming water. In a modification of this system, a nontransparent porous medium can become transparent upon penetration by water, thereby revealing a color background placed behind the porous medium.

A further preferred embodiment based on the same physical layout as that shown in FIGURE 3 uses a non-reactive system to implement the lifetime

indicator, where the migration mechanism used is the slow diffusion of a dye through a commercially available micro-porous medium. In a preferred embodiment the diffusion medium is the highly-filled micro-porous polyolefin plastic Teslin™, and the dye is red food coloring (available from McCormick & Co., Inc., Hunt Valley, MD, USA). In said embodiment, the mechanism comprises a laminated package containing a dye-impregnated paper pad, a Teslin™ strip and a thread. The thread serves to introduce water via capillary action into the package where it wets the impregnated paper pad, thereby dissolving the dye. As is obvious to one skilled in the art, drawing the liquid into the laminate package could also be performed by other means such as strands of cotton wool, filter paper, blotting paper, or small pin-prick holes made in the lower section of the laminate in the area of the metal ion. Advantageously said capillary action ensures that the dissolved dye is unable to leach out of the laminated package and potentially enter the drinking water. The resulting colored solution then proceeds to diffuse slowly through the Teslin™ strip, changing the color of said strip from white to red. As the diffusion front proceeds along the Teslin™ strip, the sharp color change which results is clearly seen from above via the partially transparent indicia mounted above the strip. Thus when a predetermined end-point is reached, the user clearly sees that the filter cartridge is supposed to be replaced. This choice of color-changing system in the preferred embodiment is especially advantageous as, even if the package were to split open, no pollution of the drinking water would occur as the food dye is a non-toxic product and the TeslinTM strip is both reagent-free and insoluble in water.

A further preferred embodiment involves the use of a significantly smaller reservoir 24 or, advantageously, no reservoir so that extent of the liquid migration performed per filling of the vessel will be limited. In this way, the lifetime indicator will function as an integrated time-volume indicator in which the lifetime of the indicator will be determined by some function of both time and filling rate. In the case where no reservoir is incorporated, then the zinc-impregnated paper pad 32 serves as a miniature reservoir collecting sufficient water at the time of each filling to drive the migration a limited distance.

Referring now to FIGURE 4, there is seen a graph showing the progress of a diffusion front in terms of the extent to which the zinc-impregnated paper pad 32

is in contact with water. The line on the graph marked 'continuous' represents the case in which the use of a sufficiently large reservoir 24 ensures that the zinc-impregnated paper pad 32 is continuously in contact with water via the thread 36. The line on the graph marked 'twice a day' represents the case in which only the zinc-impregnated paper pad 32 stores water and this pad is wetted twice per day, resulting from two fillings of the water filtration vessel per day. The line on the graph marked 'once a day' represents the case in which only the zinc-impregnated paper pad 32 stores water and this pad is wetted once per day, resulting from one filling of the water filtration vessel per day. The line on the graph marked 'every two days' represents the case in which only the zinc-impregnated paper pad 32 stores water and this pad is wetted once every two days, representing one filling of the water filtration vessel every second day. To illustrate the use of the above reservoir-free embodiment if it is desired to cause the replacement of the filter cartridge after 45 days assuming an average of one filling per day, then we learn from the, graph of FIGURE 4 that this objective is accomplished by setting the end-point of the lifetime indicator at approximately 10mm from the point at which the liquid-migration commences.

Referring now to FIGURE 5, there is seen a preferred embodiment of a masking design used to show the progress of the lifetime indicator over time. The upper surface 50 of the lifetime indicator comprises a background color together with one or more transparent sections. In a preferred embodiment, this surface is prepared by printing the required background color on a laminate while leaving clear any desired indicia such as: (a) an end-point 52 to show when the lifetime indicator has reached its end, and (b) appropriately designed indicia 51 to show the progress of the indicator towards said end-point 52. The lower surface of the laminated package 54 is shown together with the liquid-migration medium layer. As the migration or diffusion front 57 progresses along said medium, a color change is generated in the area 56 behind the front. In a preferred embodiment, this color change is from yellow to red, and thus the area 56 behind the diffusion front 57 is red and the area 58 ahead of said front is yellow. When said surface 54 is viewed from above via the upper surface 50, the resulting view 59 shows the progress of the diffusion front as a red area progressively creeping along an arrow-like shape, while the remainder of the arrow and the end-point remain

yellow. Later in time, when the end-point has also become red, the need to change the filter cartridge is clearly signaled.

In an alternative embodiment, instead of the diffusion front carrying a color change, this front can serve to turn a non-transparent medium to a transparent one. In this case a second backing color is required beneath said medium in order that this second color will show through as the diffusion front progresses.

As will be clear to one skilled in the art, various types of graphic design may be employed for the end-point, including but not limited to various lines or points. Similarly, indicia showing the progress of the diffusion front may also be employed, including but not limited to various arrows, curves, lines and points of different sizes.

Referring now to FIGURE 6, there is seen a jug-type water filtration vessel 60 with a filter cartridge 62 placed in a retention sleeve 64 between the upper chamber 66 and the lower chamber 68 of said vessel 60. On filling of the vessel 60 with water, the filter cartridge 66 becomes temporarily submerged beneath the water and this action causes the lifetime indicator 69 to admit water and thus start its timing function.

Referring now to FIGURE 7, an exemplary linear indicator is made from parts shown. A thread 1, pad 2, and strip 3 are sealed between two laminating sheets 4 to make an assembly 5. The pad 2 preferably slightly overlaps the strip 3 and the thread I is the only part that extends to the edge of the assembly 5. The thread 1 permits water to reach the pad 2. A label with an opening or transparent window affixed to the assembly 5 is shown as 6. An exemplary filter cartridge 7 is shown in side and bottom view with labeled filter assembly 6 affixed to the side near the top.

Referring now to FIGURE 8, an exemplary round indicator is made from parts shown. A pad 8 and strip 9 are sealed between two laminating sheets 10 to form an assembly 11. The central hole in pad 8 is slightly smaller than the strip 9 so there is a slight overlap when they are assembled. A cut 12 into the edge of the assembly 11 permits water to reach the pad 8. A label with an opening or transparent window affixed to the assembly is shown as 13. An exemplary filter cartridge 7 is shown in side and bottom view with labeled filter assembly 13 affixed to the bottom.

Referring now to FIGURE 9, an exemplary jug-type water filtration vessel 19 is shown side view with an exemplary attachment location 20 for a linear or round indicator. The filtration vessel 19 has a spout 14, handle 17, cap 15, reservoir 16, and cartridge 18. The exemplary attachment location 20 for the round or linear indicator is on the side of the cartridge 18 near the bottom. In this embodiment the indicator is always visible through the side of a transparent filtration vessel. In this location 20 the indicator is submerged when the filtration vessel is filled and may remain submerged until the level of water in the filtration vessel drops below the indicator location 20.

Referring now to FIGURE 10, there is shown side and top views of an alternative method of wetting the pad 7. These views show the components of the invention and also show the invention assembled 11. The components shown are the label 1, the window in the label 2, the text on the label 3 which may include indicia showing the passage of time, the top laminate 4, with the empty blister 5, and the water filled blister 6. Also shown are the pad 7, the strip 8, and the laminate 9, and the adhesive backing 10. The bottom figure on the side view and the top view is the assembled invention 11. This assembly shows the empty blister 5, the water filled blister 6 the adhesive backing 10, the window in the label 2 through which can be seen part of the strip 8, Also shown in the assembly is the text on the label 3 which may include indicia showing the passage of time.

The function of the empty blister 5 and the water filled blister 6 is to enable the user to initiate timing by pressing on the water filled blister 6 until it ruptures and forces water into the empty blister 5 which as assembled is in direct contact with the pad 7. The empty blister 5 is now water filled and in contact with the pad 7 so that said pad 7 is now wetted and will initiate timing. Further, in this deign no undesirable forces are exerted.

It will thus be seen that according to the present invention a simple and inexpensive way of providing a substantially lifetime indicator for a drinking-water filter cartridge is described, and one which may also be applicable to other devices and systems besides water dispensers. While the invention has been shown herein in what is presently conceived to be the most practical and preferred embodiment thereof, it will be apparent to those of ordinary skill in the art that many modifications may be made thereof within the scope of the invention, which

scope is to be accorded the broadest interpretation of the appended claims so as to encompass all equivalent structures and devices.

WHAT IS CLAIMED IS:

1. A substantially lifetime indicator device for a drinking-water filter comprising:

a fluid migration conduit which facilitates fluid migration therein, having a first end and a second end;

said first end having an aperture for receiving fluid, and said second end comprising a transparent section allowing an external viewer to observe a color change therein; and

a color-changing mechanism which is activated by water and positioned within said conduit, so that when water comes into contact with said indicator, a portion of the water enters said conduit first end, thereby activating said color-changing mechanism which can be viewed at said second conduit end after a predetermined time interval.

2. The device of claim 1 further comprising a porous medium in said conduit, and wherein the water that has entered said conduit via said aperture slowly migrates through said porous medium to provide a visual indication which progresses down the length of said porous medium over time.

3. The device of claim 2 further comprising a first reagent located within said conduit, and wherein the water dissolves said first reagent so that a solution containing said first reagent then migrates through said porous medium.

4. The device of claim 3 further comprising a solid dye located in said conduit and wherein the water dissolves said solid die so that dye solution then migrates through said porous medium.

5. The device of claim 4 wherein said porous medium contains a second reagent which reacts with said first reagent, thereby producing a color change.

6. The device of claim 5 wherein said porous medium is impregnated with said second reagent.

7. Th device of claim 5 wherein said porous medium is doped with said second reagent.

8. The device of claim 5 wherein the reaction system between said first and second reagents is selected from the group consisting essentially of chelation of a metal ion by a chelating agent, reaction of an acid/base with a pH indicator, reaction of an electron donor/acceptor with a redox indicator, and an enzymatic reaction between an enzyme and a substrate.

9. The device of claim 8 wherein said metal ions are selected from the group consisting essentially of zinc ions, copper ions, iron ions and calcium ions; wherein said chelating agents are selected from the group consisting essentially of 1,10 phenanthroline, zincon, and 2,2'-biquioline (cupron) and PAR; wherein said acid/base reagents are selected from the group consisting essentially of hydrochloric acid, citric acid, ascorbic acid, sodium hydroxide and sodium hydrogen phosphate; wherein said pH indicators are selected from the group consisting essentially of bromothymol blue, methyl red and cresol red; wherein said electron donor/acceptors are selected from the group consisting essentially of bleaching powder and vanadium salts; and wherein said redox indicators are selected from the group consisting essentially of nphenylanthrancilic acid and bleachable dyes.

10. The device of claim 2 wherein said porous medium is selected from the group consisting essentially of cellulose-based material, paper, sol-gel, silica gel, polymeric micro-porous materials, and particle-filled polytetrafluroethylene.

11. The device of claim 10 wherein said porous medium is composed of a combination of at least two of said porous materials.

12. The device of claim 2 wherein the mechanism for migration down the length of said porous medium is selected from the group consisting essentially of diffusion and capillary action.

13. The device of claim 2 wherein said porous medium is initially opaque and the migration of the water into its pores causes said porous medium to

become substantially transparent, thereby resulting in a visually observable change.

14. The device of claim 1 where said porous medium has a colored background located therebelow so that when said porous medium becomes substantially transparent and the background color shows through and can be observed from above as a visible color change.

15. The device of claim 4 where said porous medium is colored by the migration of said dye solution into its pores, resulting in a visually observable change.

16. The device of claim 1 where said fluid migration conduit employs capillary action to draw water towards said color-changing mechanism.

17. The device of claim 1 where said indicator further comprises a water reservoir serving to drive the migration of fluid through said color changing mechanism; and wherein the volume of said reservoir determines the extent of migration through said color-changing mechanism.

18. The device of claim 17 where said reservoir is sufficiently large to drive said migration after only one contact of the water filter with water, so that one filling of the water filter is sufficient to drive said indicator for the entire lifetime of said water filter cartridge.

19. The device of claim 17 where said reservoir is sufficiently small so as to only drive said migration by a small amount, so as to implement a relationship between the number of fillings of the water filter and the extent of said migration, so that the indicator determines the lifetime of the water filter by also taking into consideration the number of times that the water filter is refilled.

20. The device of claim 1 where said indicator further comprises a partially transparent mask located above said conduit second end, said mask presenting the underlying color change of the said color-changing mechanism via graphic

indicia located on said mask by one or more transparent windows enabling the underlying color change to show through.

21. The device of claim 1 where said color-changing mechanism displays a gradual advance of said color change over time.

22. A substantially lifetime indicator device for a water filter comprising:

a small water reservoir for capturing water at the time that a water filter is filled;

an element wicking the water into contact with a pad containing a zinc salt so that the zinc ions located on said pads are carried into solution;

a diffusion strip formed by dipping paper in sol-gel doped with the chelating agent PAR; and

said reservoir element and strip positioned so that said solution slowly diffuses through said diffusion strip where the zinc ions undergo a chelation reaction with the PAR, yielding a color change from yellow to red, and so that the diffusion front of said color change slowly proceeds along said paper strip and is viewed via a mask containing indicia that relate the progress of said diffusion front to the effective lifetime of the water filter.

23. A substantially lifetime indicator device for a water filter comprising:

a small water reservoir for capturing water at the time that a water filter is filled,

a thread drawing the water into contact with a pad containing a dye so that the dye is carried into solution,

a diffusion strip comprising a micro-porous material; and

wherein said reservoir, thread and diffusion strip are positioned so that said solution slowly diffuses through said diffusion strip so that the said diffusion strip undergoes a color change due to the absorption of said dye, and so that the diffusion front of said color change slowly proceeds along said diffusion strip and is viewed via a mask containing indicia that relate the progress of said diffusion front to the effective lifetime of the water filter.

24. A substantially lifetime indicator device for a drinking-water filter wherein said indicator comprises a liquid which migrates slowly through a porous media resulting in an observed color change, and wherein the appearance of said color change corresponds to the intended effective lifetime of said water filter.

25. A drinking-water filter cartridge incorporating filtration media and the indicator of claim 1.

26. A device as described in claim 24 incorporating a self-contained but independent water reservoir which may be manipulated in such a manner as to bring the contained water into contact with the timing mechanism in such a manner as to actuate the timing function.

27. The device of claim 21 modified to incorporate a scale to display the elapsed time.

28. A method of indicating the expiration of substantially the predetermined useful life of a water filter comprising:

operatively connecting a water filter, a pad containing a zinc salt or dye, and a diffusion strip of sol-gel doped with PAR dipped paper;

drawing water associated with the filter into contact with the pad to produce a solution;

slowly diffusing the solution through the diffusion strip so as to produce a color change; and

viewing the color change via a mask containing indicia that relates the progress of the diffusion to substantially the predetermined useful life of the filter.

29. An indicator and method for indicating the useful life of a product, substantially as shown and described.

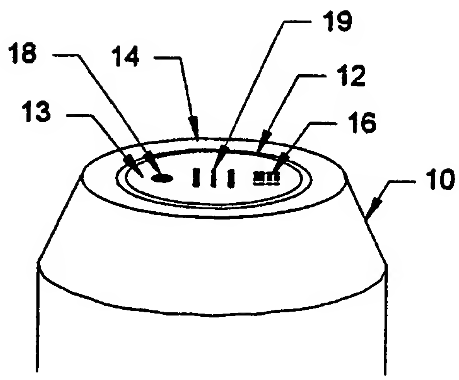


Figure 1

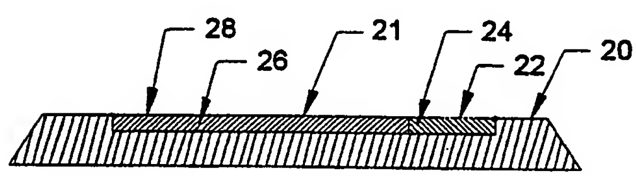


Figure 2

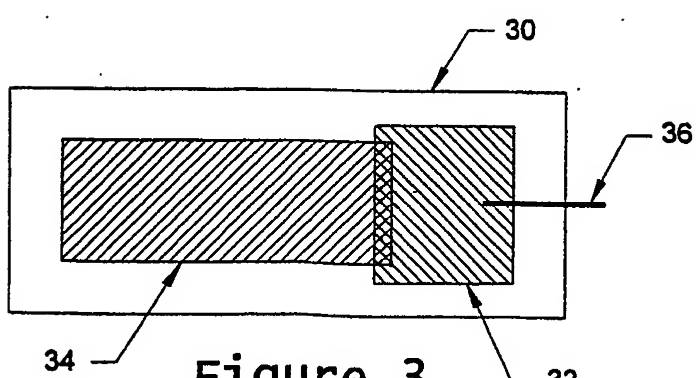


Figure 3

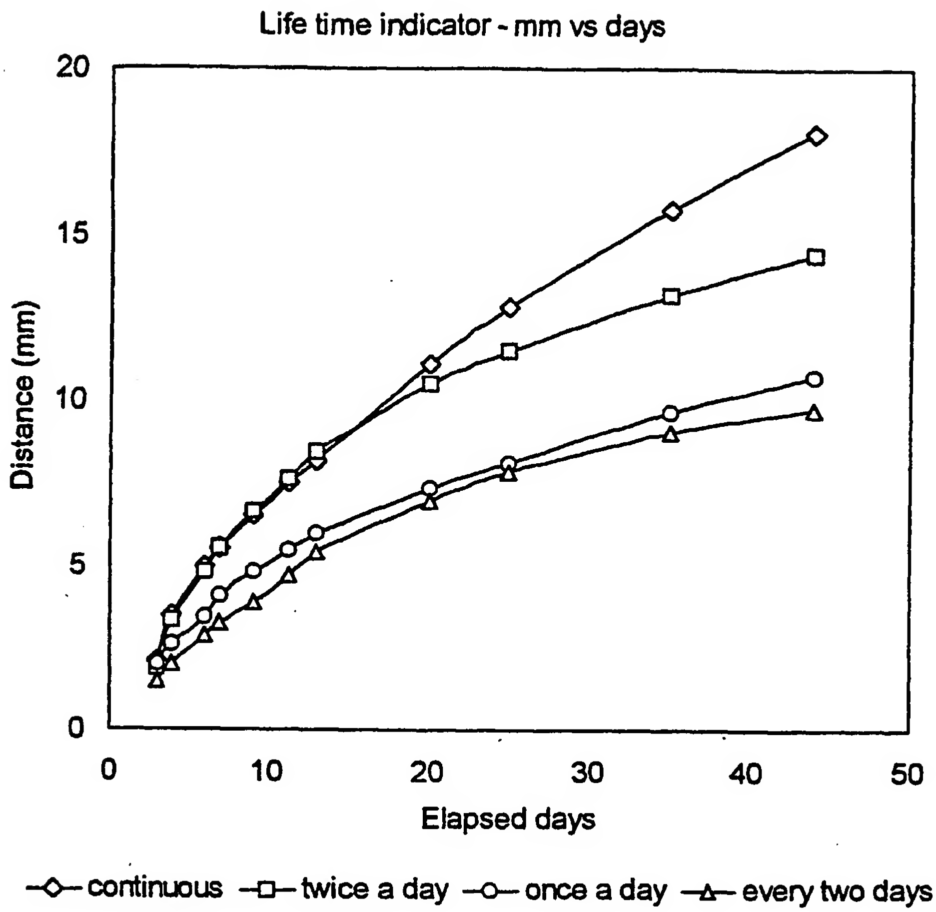

Life time indicator - mm vs days
Distance (mm)
0
5
10
15
20
0
10
20
30
40
50
Elapsed days
continuous
twice a day
once a day
every two days

Figure 4

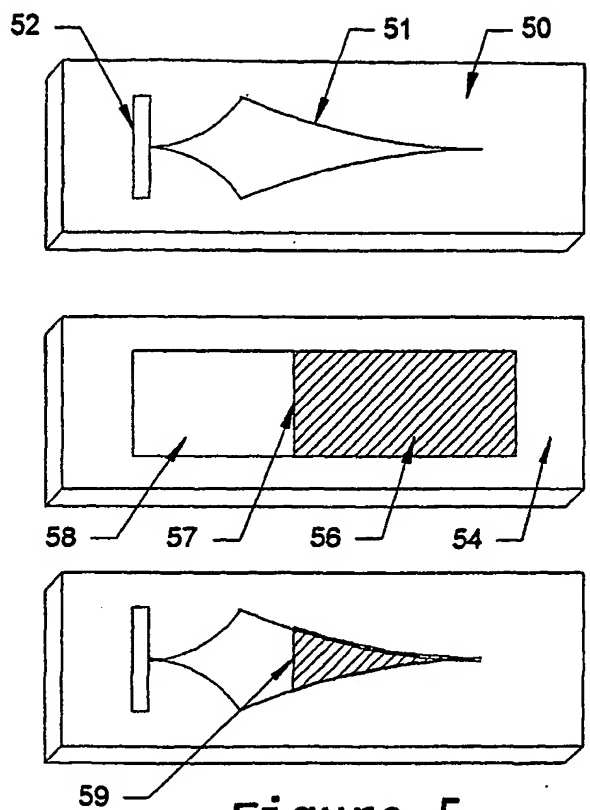
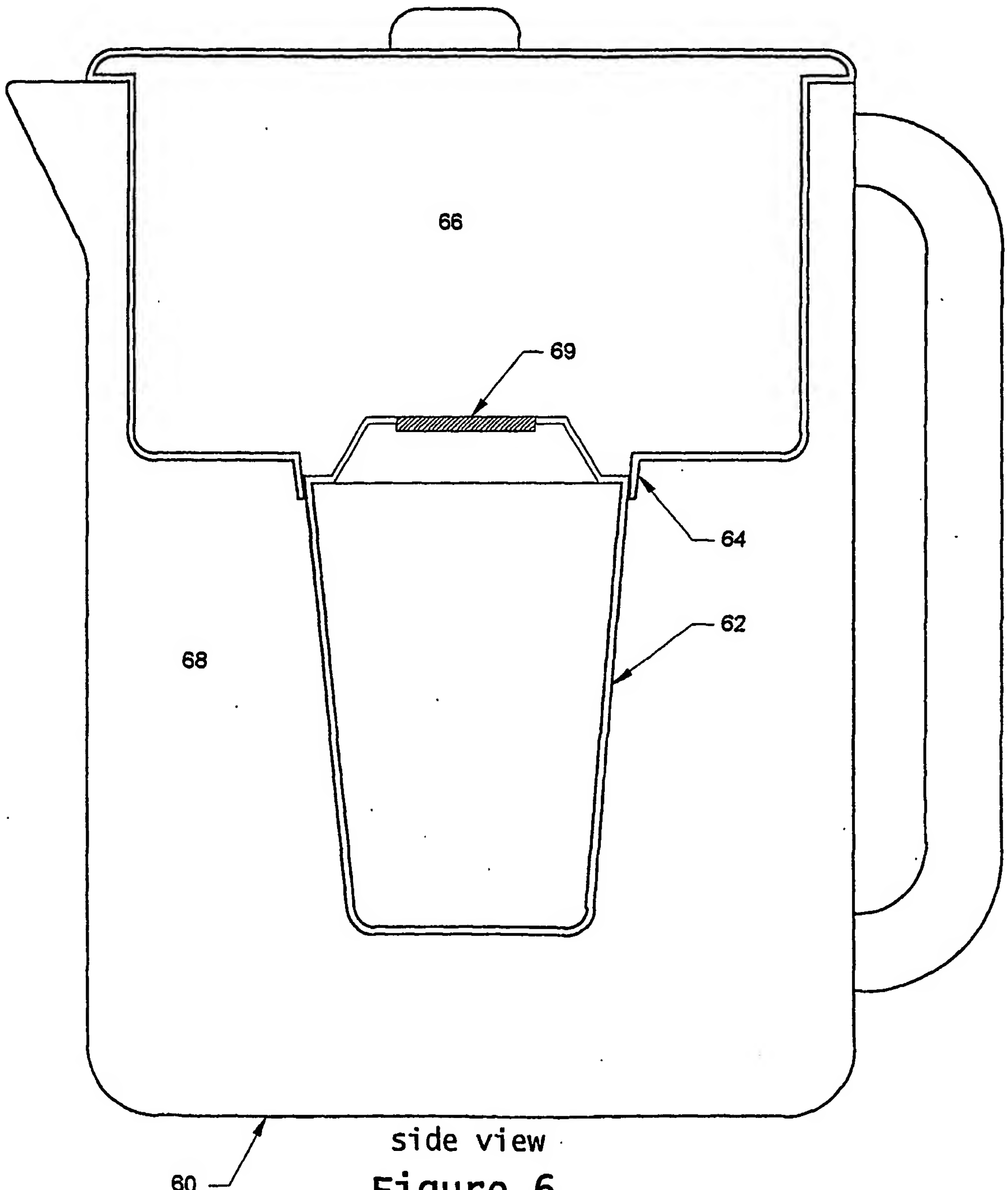


Figure 5



side view

Figure 6

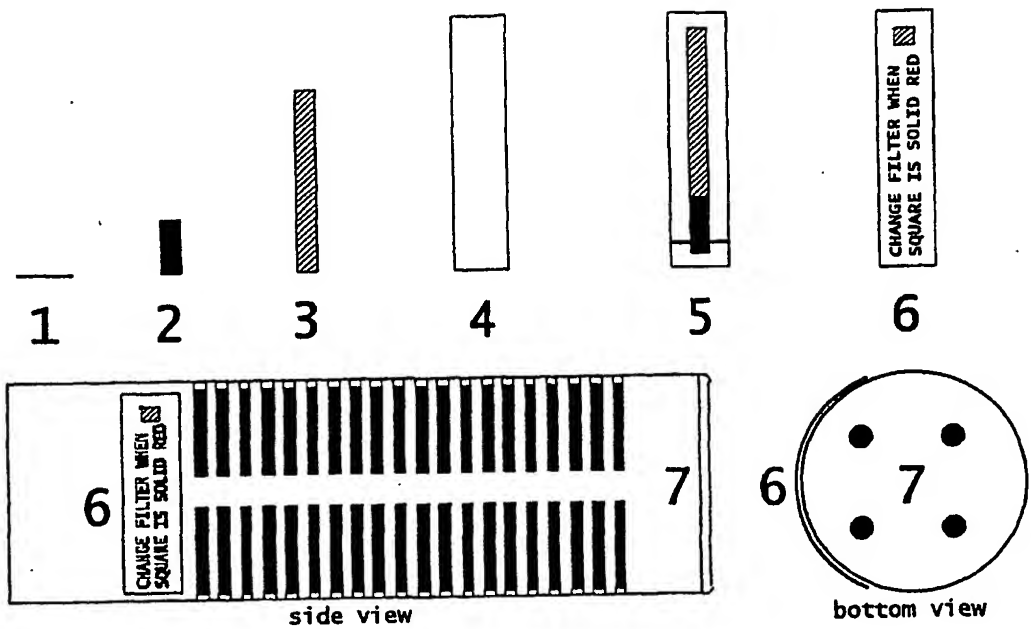


Figure 7

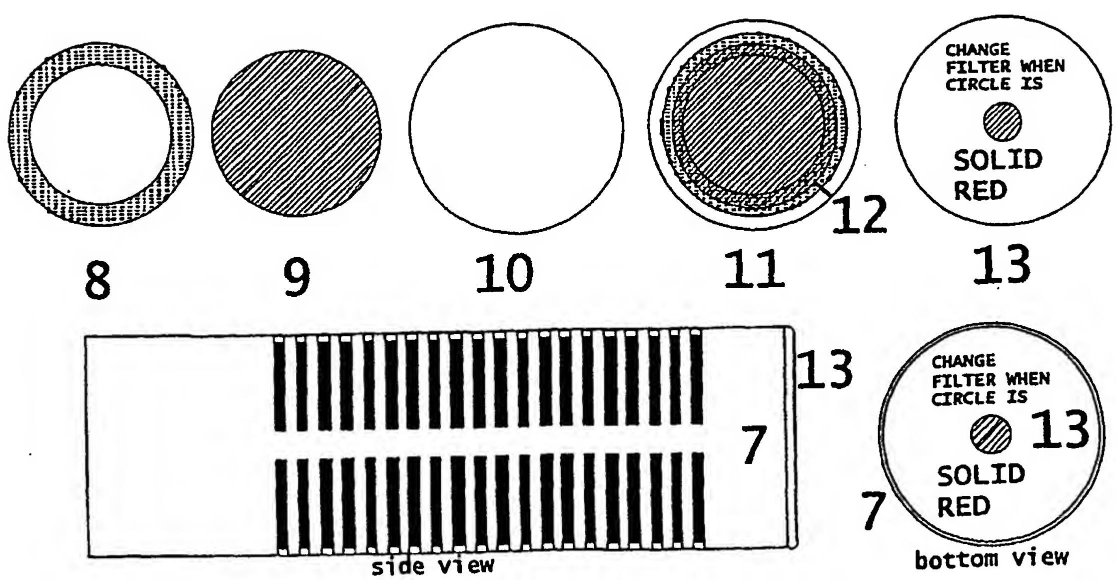
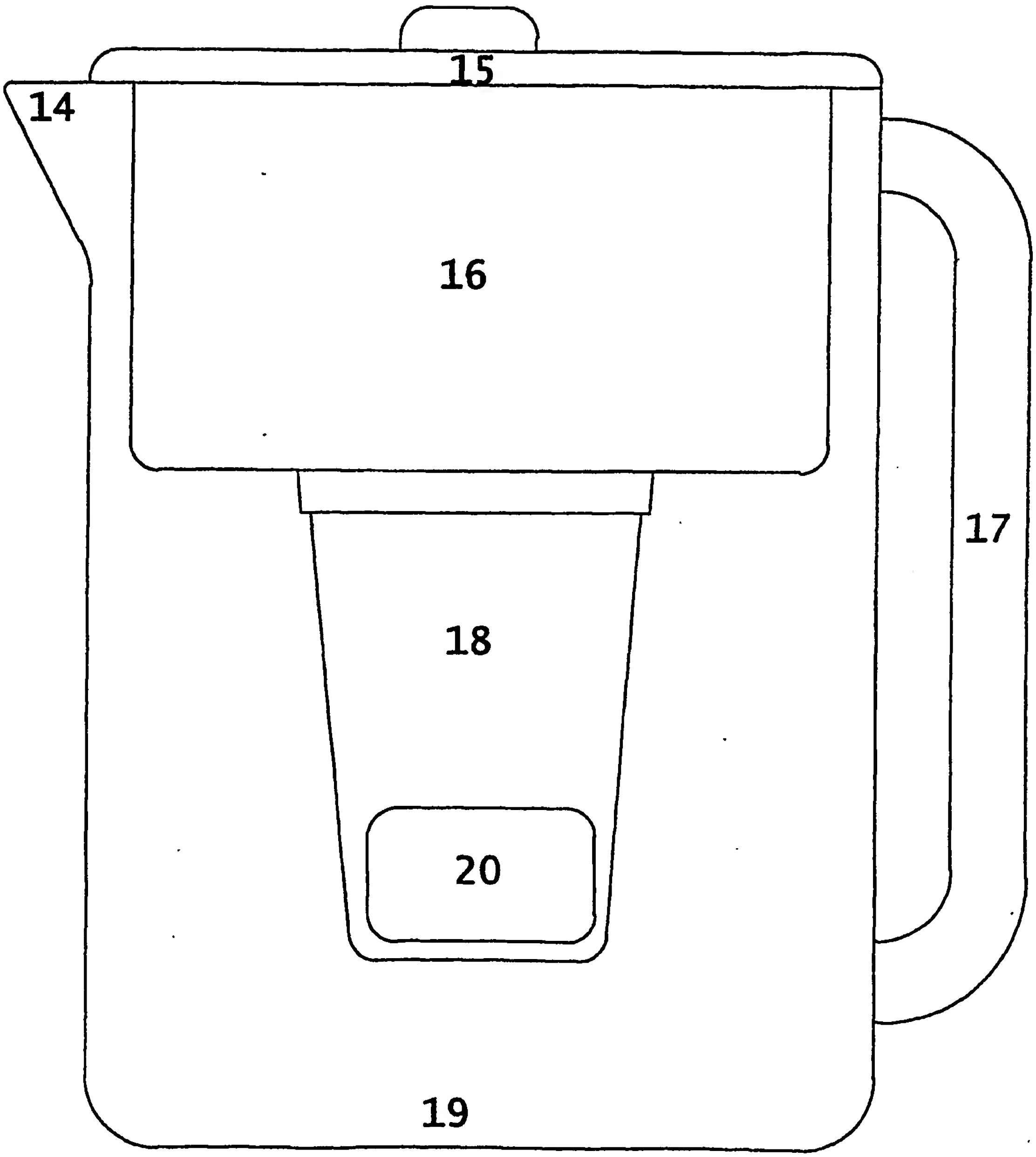
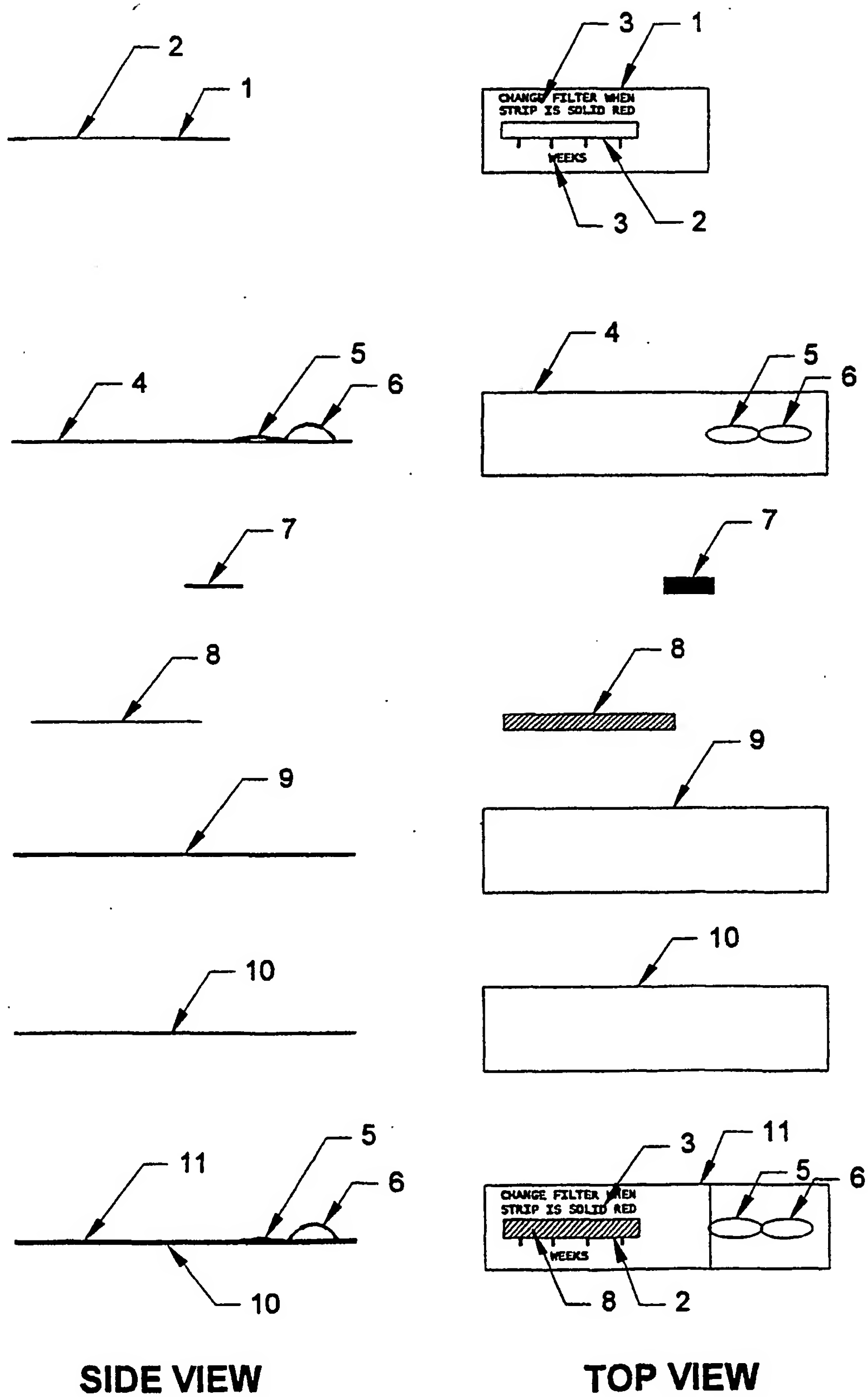


Figure 8



side view

Figure 9


2
1
3
1
CHANGE FILTER WHEN
STRIP IS SOLID RED
WEEKS
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6
CHANGE FILTER WHEN
STRIP IS SOLID RED
WEEKS
8
2
SIDE VIEW
TOP VIEW

Figure 10

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